Abstract

The goal of this thesis is to develop a hybrid finite element formulation to carry out stress analysis of arteries. To the best of our knowledge, a hybrid finite element implementation of the Holzapfel-Ogden artery model has not been carried out before. Since arteries are thin 'shell-type' structures, they are subjected to membrane, shear and volumetric locking in case when standard finite elements are used. Since hybrid finite elements are known to overcome these problems, we develop hybrid hexahedral element formulations (both lower and higher-order) for artery analysis. We demonstrate the better coarse mesh accuracy of hybrid elements, which are based on a two-field variational formulation, over conventional displacement based elements. Typically, we find that three or four extra levels of refinement are required with conventional elements to achieve the same accuracy as hybrid elements.

The recently proposed Holzapfel-Ogden constitutive model for the artery and its implementation both within the conventional and hybrid finite element frameworks is discussed. The numerical implementation is particularly challenging due to the presence of fibers which can only take tensile loads. The mathematically exact tangent stiffness matrix that we have derived in this work is crucial in ensuring convergence of the numerical strategy.

Keywords: *biomechanics, hybrid elements, anisotropy, finite deformations, nonlinear elasticity.*